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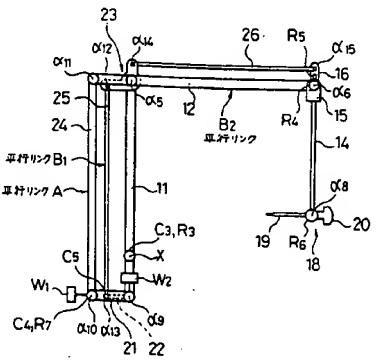
(54) **Medical locating apparatus.**

(57) In the medical locating apparatus of the invention, the main parallel link (A) and the subsidiary parallel links (B1,B2) are formed by the first to third links (11-12,14), the first to third sub-links (24,25,26) and the crank member (23), in which the respective links are interlocked with the corresponding parallel links, respectively. Accordingly, clutch (C) means need not be disposed to all of the connection shafts of the links, but they may be disposed only to the pivot locating relatively at a low position, to the connection shaft connecting the first auxiliary link (21) with the first sub-link (24) and to the connection shaft connecting the second auxiliary link (22) with the second sub-link (25). Thus, the links need not be operated by the respective heavy clutches, the present apparatus enjoys excellent operability, and such constitution is also preferred from the standpoint of stability of the entire apparatus.

FIG.2



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BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a medical locating apparatus, particularly to a medical locating apparatus which can suitably be used in brain surgery.

2. Description of the Prior Art

As CT scanners and MRI scanners are becoming very popular, neurosurgery has encountered a turning point. Namely, the conventional diagnostic imaging such as cranial plain roentgenography and cerebral angiography are now predominantly being replaced by the three-dimensional diagnostic imaging based on computerized analysis data in the field of brain surgery.

In order to reproduce such locational information specified on the image of CT scanning and the like, a medical locating apparatus which locates the site which needs surgical operation, as disclosed, for example, in Japanese Provisional Patent Publication No. 327/1987, is employed. The medical locating apparatus of the disclosure consists of a plurality of arms provided on a bed, a plurality of potentiometers disposed to the joints of the respective arms and an indicating unit disposed at the tip of the arm, by which the site to be operated is detected based on the signal from the potentiometers.

However, since the arms in such conventional medical locating unit are designed to be moved via the respective joints, clutch means must be provided on all of the joints so as to stop the entire locating apparatus. To dispose a heavy clutch means at a high position near the indicating unit is not preferred in view of operability and stability of the locating apparatus.

Meanwhile, since the angles of the respective joints are detected by the potentiometers, the apparatus are not only required to have an A/D converter but also readily affected by the temperature change.

Further, since the weight of each arm is not well-balanced, operation of the arms requires a great operating physical force, presenting poor operability, disadvantageously.

SUMMARY OF THE INVENTION

This invention was accomplished noting such prior art technique and provides a medical locating apparatus which has excellent operability and requires neither clutch means to the joint which is brought close to the patient nor A/D conversion, and which is not affected by the temperature change.

In order to attain the intended object as described above, the medical locating apparatus according to this invention comprises a first link pivotally supported at the middle on the pivot assumed on a bed; a second link pivotally supported at the middle on the upper end portion of the first link; a third link pivotally supported at the middle on one end portion of the second link; a crank member pivotally disposed to a connection shaft connecting the first link with the second link; a first auxiliary link and a second auxiliary link both pivotally supported at one end portions respectively onto the lower end portion of the first link; a first sub-link, which is parallel with the first link, connecting the other end portion of the first auxiliary link with the other end portion of the second link; a second sub-link, which is parallel with the first link, connecting the other end portion of the second auxiliary link with one end portion of the crank member; a third sub-link, which is parallel with the second link, connecting the other end portion of the third link with the other end portion of the crank member; wherein the third link is designed to be rotatable on the longitudinal axis thereof and has an indicating unit at the lower end thereof; the pivot, and the connection shaft connecting the first auxiliary link with the first sub-link are provided with magnetic clutches and rotary encoders, respectively; the connection shaft connecting the second auxiliary link with the second sub-link is provided with a magnetic clutch; while the connection shaft connecting the second link with the third link, the rotary shaft, i.e. the longitudinal axis, of the third link and the rotary shaft of the indicating unit are provided with rotary encoders, respectively.

The locating unit according to another aspect of the invention further comprises a first counter weight and a second counter weight, which are provided to the other end of the first auxiliary link to protrude horizontally therefrom and to one end portion of the second auxiliary link to protrude upward therefrom, respectively; in which the first counter weight and the second counter weight interlock with the first auxiliary link and the second auxiliary link, respectively.

Incidentally, in the above and following descriptions, while the expression "link" substantially means the numbered link arm, it indirectly also means the linkage including the link arm; and the expression "to pivot" means that the both end portions of the link are swung like a seesaw on the fulcrum assumed at the middle thereof, whereas the expression "to rotate" means that the link rotates on the longitudinal axis thereof like a drill.

According to the medical locating unit as set forth in the appended Claim 1, first to third links, first to third sub-links and a crank member constitute a main parallel link and subsidiary parallel links. Since the respective links are interlocked respectively with the corresponding parallel links, clutch means need not be disposed to all of the shafts connecting the links, but only to the pivot locating at a relatively low position, to the connection shaft connecting a first auxiliary link with the first sub-link and to the connection

shaft connecting a second auxiliary link with the second sub-link. Accordingly, the links need not be operated by the respective heavy clutches, the present apparatus enjoys excellent operability, and such constitution is also preferred from the standpoint of stability of the entire apparatus.

Further, since the angles of the links are detected by rotary encoders which require no A/D conversion and are not affected by the temperature change, the present apparatus also enjoys excellent locating accuracy.

According to the locating apparatus as set forth in Claim 2, a first counter weight and a second counter weight are provided to project horizontally from the other end of the first auxiliary link and upward from one end portion of the second auxiliary link to pivot interlocking therewith, respectively, the links can be operated with a very small operating physical force, providing excellent operability.

The gist of the invention is not limited to the above description, and the objects of the invention together with the advantages, features and applications thereof will be apparent by reading the following description taken in conjunction with the attached drawings. It should be understood that suitable modifications or variations without departing from the spirit of the invention are all included in the scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows perspectively a medical locating apparatus according to one embodiment of the invention;

Fig. 2 shows schematically in side view the structure above and including the first link;

Fig. 3 shows schematically in side view the structure shown in Fig. 2, in which the third link is pivoted;

Fig. 4 shows schematically in side view the structure shown in Fig. 2, in which the second link is pivoted; and

Fig. 5 shows schematically in side view the structure shown in Fig. 2, in which the first link is pivoted.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the invention will be described below referring to the attached drawings. A patient P lies on a bed 1. (In Fig. 1, the bed 1 is depicted extremely schematically.) A horizontal shaft 2 is fixed to the head end of the bed 1 to be parallel with the longitudinal direction of the bed 1. The horizontal shaft 2 is secured between a pair of jaws 3a, consisting of an upper jaw and a lower jaw, of an L-shaped metal fitting 3. Meanwhile, another horizontal shaft 4 is secured between the other pair of jaws 3b, also consisting of an upper jaw and a lower jaw, of the L-shaped metal fitting 3 to be parallel with the transversal direction of the bed 1. The clamping force of these two pairs of jaws 3a,3b can be adjusted by levers 5, respectively, so that the horizontal shafts 2,4 can be rotated on the longitudinal axes α_1, α_2, respectively.

A first bracket 6 is fixed to the horizontal shaft 4 extended parallel to the transverse direction of the bed 1, and a perpendicular shaft 7, which is rotatable on the axis α_3 thereof, is disposed on the first bracket 6. On the perpendicular shaft 7 are disposed a magnetic clutch C_1 and a rotary encoder R_1. The angles in the apparatus of the invention are all detected out by rotary encoders which require no A/D conversion and are hardly affected by the temperature. A second bracket 8 is also secured on the upper end of the perpendicular shaft 7, and another horizontal shaft 9, which is rotatable on the axis α_4, is supported on the second bracket 8. The horizontal shaft 9 is also provided with a magnetic clutch C_2 and a rotary encoder R_2. A third bracket 10 having an L-shaped cross section is provided at the other end of the horizontal shaft 9.

A vertical first link 11 is pivotally supported at the middle onto the pivot X assumed on the third bracket 10. A magnetic clutch C_3 and a rotary encoder R_3 are provided on the pivot X. A second link 12 is pivotally supported at the middle onto the upper end portion of the first link 11 by a connection shaft α_5. A tip metal fitting 13 is attached to the tip of the second link 12, and a pivotal metal fitting 15 is pivotally supported on the connection shaft α_6 disposed to the tip metal fitting 13, the pivotal metal fitting 15 being secured at the middle of a third link 14. The connection shaft α_6 is also provided with a rotary encoder R_4. The third link 14 is attached to the pivotal metal fitting 15 to be rotatable on the longitudinal axis α_7 thereof. A lever 16 is formed integrally with the pivotal metal fitting 15 to project upward therefrom, on which a rotary encoder R_5 for detecting the rotational amount of the third link 14 is mounted. (It should be noted, however, that the rotary encoder R_5 is depicted intentionally smaller than the actual relative size for clearer understanding of the relationship with other parts.) Incidentally, the tip metal fitting 13 has a notch 17 for avoiding interference with the upper end portion of the third link 14.

An indicating unit 18 is pivotally supported by a connecting shaft α_6 as a rotary shaft to the lower end portion of the third link 14. The indicating unit 18 is provided with an indicating needle 19 and a counter weight 20 on each side of the connecting shaft α_8, so that the weight of the indicating needle 19 and that of the counter weight 20 may be balanced at the connection shaft α_8. The connection shaft α_8 is provided with a rotary encoder R_6. The main link system is as described above, and sub-link systems are combined therewith.

Namely, a first auxiliary link 21 and a second auxiliary link 22 are pivotally supported at one end portions thereof on the connection shaft α_9 provided on the lower end of the first link 11, respectively, the former being longer than the latter. A crank member 23 is also pivotally supported on the connection shaft α_5 connecting the first link 11 and the second link 12. The connection shaft α_{10} provided at one end portion of the first auxiliary link 21 and the connection shaft α_{11} provided at the other end portion of the second link 12 are connected by a first sub-link 24 which is parallel with the first link 11. The connection shaft α_{10} is provided with a magnetic clutch C_4 and a rotary encoder R_7. A first counter weight W_1 which can be pivoted interlocking with the first auxiliary link 21 is provided on the magnetic clutch C_4, disposed on the other end of the first auxiliary link 21, to protrude in the horizontal direction. A second counter weight W_2 which can be pivoted interlocking with the second auxiliary link 22 is provided on the connection shaft α_9 provided at one end portion of the second auxiliary link 22 to protrude upward. The connection shaft α_{13} provided at the other end portion of the second auxiliary link 22 and the connecting shaft α_{12} disposed at one end portion of the crank member 23 are connected by a second sub-link 25 which is parallel with the first link 11. The connection shaft α_{13} is provided with a magnetic clutch C_5. Further, the connection shaft α_{14} provided at the other end portion of the crank member 23 and the connecting shaft α_{15} of the lever 16 of the rotary metal fitting 15 are connected by a third sub-link 26 which is parallel with the second link 12.

As described above, in the apparatus according to this embodiment, the connection shaft $\alpha_5 \rightarrow$ connection shaft $\alpha_9 \rightarrow$ connection shaft $\alpha_{10} \rightarrow$ connection shaft α_{11} constitute a main parallel link A; the connection shaft $\alpha_5 \rightarrow$ connection shaft $\alpha_9 \rightarrow$ connection shaft $\alpha_{13} \rightarrow$ connection shaft α_{12} constitute a first subsidiary parallel link B_1; and the connection shaft $\alpha_5 \rightarrow$ connection shaft $\alpha_6 \rightarrow$ connection shaft $\alpha_{15} \rightarrow$ connection shaft α_{14} constitute a second subsidiary parallel link B_2.

The action of the mechanism will now be described. The structure above and including the first link 11 is designed to be rotatably in the vertical and horizontal directions with the aid of the shafts α_1 to α_4. Referring now only to the action of the sub-link system, when the third link 14 is pivoted on the connection shaft α_6, as shown in Fig. 3, the shape of the second subsidiary parallel link B_2, and that of the first subsidiary parallel link B_1 are modified, and the amount of modification (i.e. the pivoted angle of the third link 14) can be detected by the rotary encoder R_4. Further, this motion can be locked by the magnetic clutch C_5. The third link 14 can be operated with a small operating physical force with the aid of the second counter weight W_2.

Next, when the second link 12 is pivoted upward on the connecting shaft α_5, as shown in Fig. 4, the shape of the main parallel link A and the second subsidiary parallel link B_2 are modified, and the amount of modification (i.e. the pivoted angle of the second link 12) can be detected by the rotary encoder R_7 disposed to the connection shaft α_{10}. Since the crank member 23 is not pivoted in this process, the vertical posture of the third link 14 can be maintained as such. Incidentally, this motion can be locked by the magnetic clutch C_4. Further, the second link 12 can be operated with a small operating physical force with the aid of the first counter weight W_1.

Subsequently, when the first link 11 is pivoted on the pivot X to modify the shape of the main parallel link A so as to bring the third link 14 farther, the pivoted angle of the first link 11 (the shift of the indicating unit 18) can be detected by the rotary encoder R_7. This motion can be locked by the magnetic clutch C_4. Further, the first link 11 can also be operated with a small operating physical force with the aid of the first counter weight W_1. Besides, since the crank member 23 is not pivoted either in this process, the vertical posture of the third link 14 can be maintained as such.

Meanwhile, the rotational amount of the third link 14 on the longitudinal axis α_7 thereof can be detected by the rotary encoder R_6, while the pivoted angle of the indicating unit 18 can be detected by the rotary encoder R_6. Accordingly, the location of the tip of the indicating unit 18 can be detected based on the signals from the respective rotary encoders R_1 to R_7, so that the tip of the indicating unit 18 can be guided to the desired point based on the positional information from the CT scanner and the like. Besides, in the apparatus according to this embodiment, while the respective links can be operated freely on the pivot X and on the other connection shafts α_5..., the motions thereof can be locked by the magnetic clutches C_3 to C_6 disposed therebelow respectively. Accordingly, no heavy clutch means is needed to be disposed to the connection shaft α_6 which is brought close to the head of the patient P, providing excellent operability and stability.

The constitution of the medical locating apparatus according to this invention is as described above, and the main parallel link and the subsidiary parallel links are formed by the first to third links, the first to third sub-links and the crank member, in which the respective links are interlocked with the corresponding parallel links, respectively. Accordingly, clutch means need not be disposed to all of the connection shafts of the links, but they may be disposed only to the pivot locating relatively at a low position, to the connection shaft connecting the first auxiliary link with the first sub-link and to the connection shaft connecting the second auxiliary link with the second sub-link. Thus, the links need not be operated by the respective heavy clutches, the present apparatus enjoys excel-

lent operability, and such constitution is also preferred from the standpoint of stability of the entire apparatus.

Further, the angles of the links are detected by rotary encoders which require no A/D conversion and are not affected by the temperature change, the present apparatus also enjoys excellent locating accuracy.

Moreover, since the first counter weight, which is disposed to protrude horizontally from the other end portion of the first auxiliary link to protrude and can be pivoted interlocking therewith, and the second counter weight, which is disposed to protrude upward from one end portion of the second auxiliary link and can be interlocked therewith are provided, respectively, the links can be operated with a very small physical force, providing excellent operability.

Claims

1. A medical locating apparatus, comprising:

a first link pivotally supported at the middle on the pivot assumed on a bed;

a second link pivotally supported at the middle on the upper end portion of said first link;

a third link pivotally supported at the middle on one end portion of said second link;

a crank member disposed to a connection shaft connecting said first link with said second link;

a first auxiliary link and a second auxiliary link both pivotally supported at one end portions respectively onto the lower end portion of said first link;

a first sub-link, which is parallel with said first link, connecting the other end portion of said first auxiliary link with the other end portion of said second link;

a second sub-link, which is parallel with said first link, connecting the other end portion of said second auxiliary link and one end portion of said crank member;

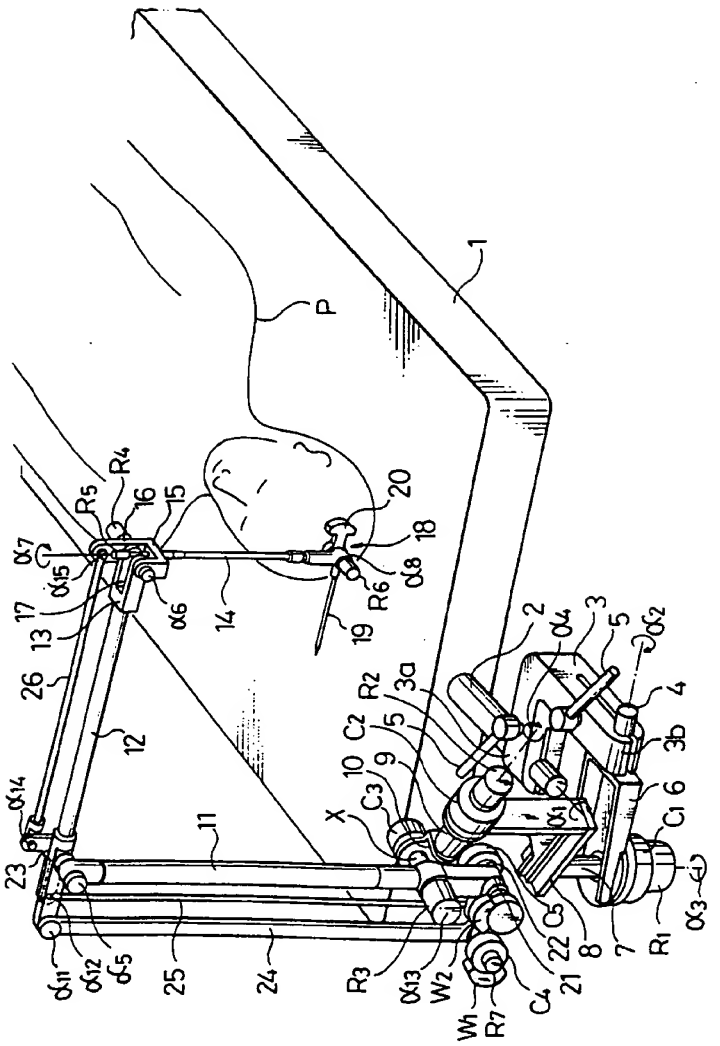
a third sub-link, which is parallel with said second link, connecting the other end portion of said third link with the other end portion of said crank member;

wherein said third link is designed to be rotatable on the longitudinal axis thereof and has an indicating unit at the lower end thereof; said pivot, and the connection shaft connecting said first auxiliary link with said first sub-link are provided with magnetic clutches and rotary encoders, respectively; the connection shaft connecting said second auxiliary link with said second sub-link is provided with a magnetic clutch; while the connection shaft connecting said second link with said third link, the rotary shaft, i.e. the longitudinal axis, of said third link and the rotary shaft of said indicating unit are provided with rotary encoders, respectively.

2. The medical locating apparatus according to Claim 1,

wherein a first counter weight and a second counter weight are provided to the other end of said first auxiliary link to protrude horizontally therefrom and to one end portion of said second auxiliary link to protrude upward therefrom, respectively; said first counter weight and said second counter weight interlocking with said first auxiliary link and said second auxiliary link, respectively.

FIG.1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21
22
23
24
25
26
3a
3b
X
R1
R2
R3
R4
R5
R6
R7
C1
C2
C3
C4
C5
W1
W2
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α3
α4
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α6
α7
α8
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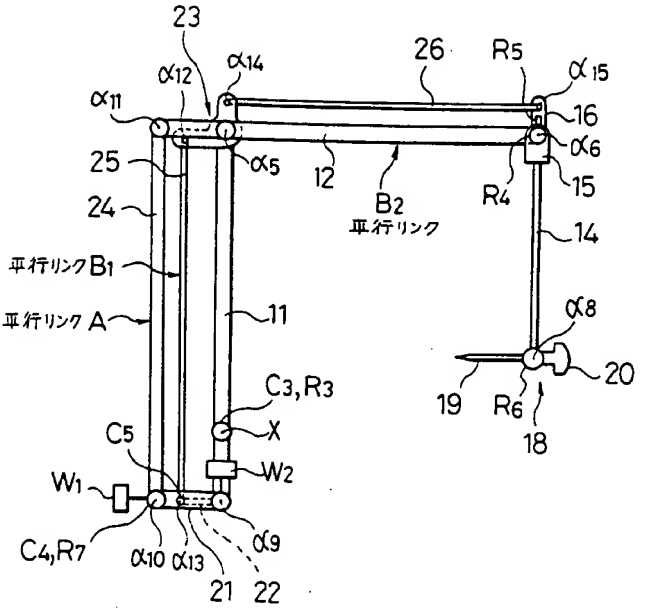
α12
α13
α14
α15

FIG.2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α14
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R5
α15
α11
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α6
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α5
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B2
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R4
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14
平行リンクB1
平行リンクA
11
α8
20
C3,R3
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R6
18
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C5
W2
W1
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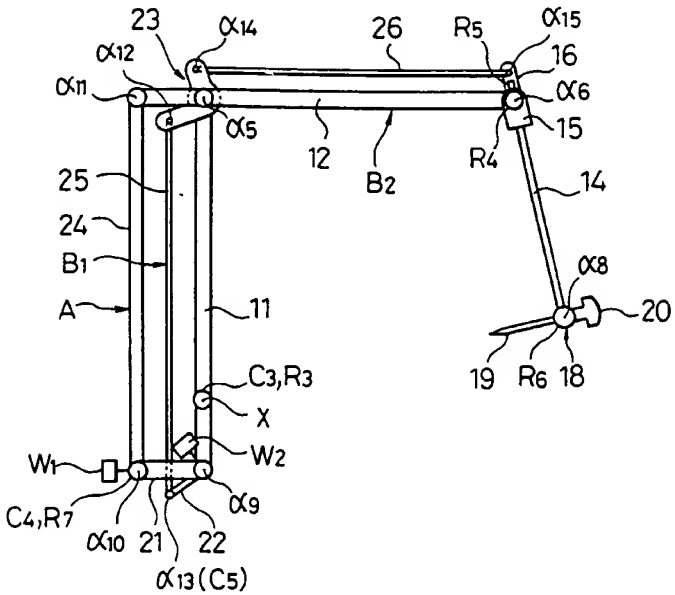
α10
α13
α9
21
22

FIG.3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B2
R4
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α8
A
11
20
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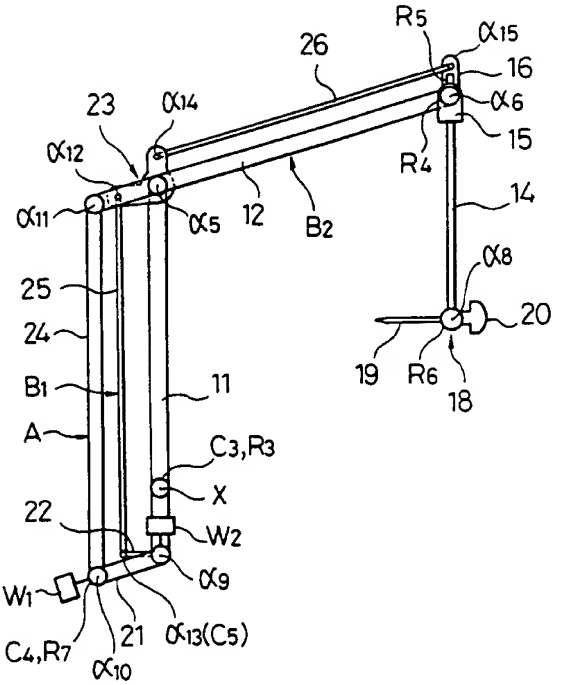
W1
α9
C4,R7
α10
21
22
α13(C5)

FIG.4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19
R6
18
B1
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A
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W2
α9
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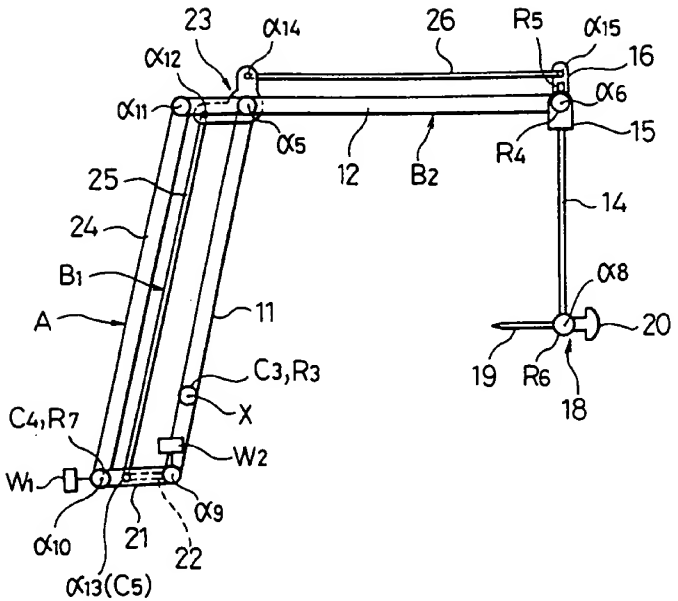
α13(C5)
C4,R7
α10

FIG.5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W2
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22
α13(C5)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 0617

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	EP-A-0 419 070 (MITAKA KOHKI CO.,LTD.) * column 3, line 53 - column 7, line 7; figures 1-8 *	1,2	A61B19/00 F16M11/12
A	EP-A-0 023 003 (CONTRAVES A.G.) * page 5, line 18 - page 6, line 6 * * page 7, line 26 - line 29; figure 1 *	1,2	
A	US-A-5 050 608 (E.WATANABE ET AL) * column 2, line 6 - line 29; figures 1,2 *	1	
A	FR-A-2 660 185 (MEDIRAND, INC.) * page 4, line 6 - page 5, line 17; figure 1 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

A61B
F16M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	26 April 1994	Weihs, J

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